

Advancement of Electrochromic Windows: Summary of Technology Transfer Activities

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Journal Articles¹

- Lee, E.S., D. L. DiBartolomeo. 2002. Application issues for large-area electrochromic windows in commercial buildings. *Solar Energy Materials & Solar Cells* 71 (2002) 465–491. LBNL Report 45841, Lawrence Berkeley National Laboratory, Berkeley, CA.
- Lee, E.S., D.L. DiBartolomeo, F.M. Rubinstein, S.E. Selkowitz. 2004. Low-Cost Networking for Dynamic Window Systems. *Energy and Buildings* 36(6):503-513. LBNL-52198, Lawrence Berkeley National Laboratory, Berkeley, CA.
- Tavit, A. and E.S. Lee. 2005. The impact of overhang design on the performance of the electrochromic windows. *Proceedings of the International Solar Energy Society (ISES) Solar World Congress*, Orlando, Florida on August 8-12, 2005. LBNL-57020.
- Lee, E.S. and A. Tavit. 2005. An assessment of the visual comfort and energy performance of electrochromic windows with overhangs. Submitted to *Building and Environment*, November 3, 2005, and accepted for publication April 11, 2006. LBNL-59064, Lawrence Berkeley National Laboratory, Berkeley, CA.
- Lee, E.S., D.L. DiBartolomeo, S.E. Selkowitz. 2005. Daylighting control performance of a thin-film ceramic electrochromic window: Field study results. *Energy and Buildings* 38 (2006) 30-44. LBNL-54924, Lawrence Berkeley National Laboratory, Berkeley, CA.
- Lee, E.S., D.L. DiBartolomeo, J. Klems, Ph.D., M. Yazdanian, S.E. Selkowitz. 2006. Monitored Energy Performance of Electrochromic Windows Controlled for Daylight and Visual Comfort. To be presented at the ASHRAE 2006 Annual Meeting, Quebec City, Canada, June 24-28, 2006 and published in *ASHRAE Transactions*. LBNL-58912.
- Clear, R.D., V. Inkarojrit, E.S. Lee. 2006. Subject responses to electrochromic windows. Submitted to *Energy and Buildings* February 23, 2005 and accepted for publication March 1, 2006. LBNL-57125.

Conference Papers²

- Lee, E.S., S.E. Selkowitz, M.S. Levi, S.L. Blanc, E. McConahey, M. McClintock, P. Hakkarainen, N.L. Sbar, M.P. Myser. 2002. “Active Load Management with Advanced Window Wall Systems: Research and Industry Perspectives”. *Proceedings from the ACEEE 2002 Summer Study on Energy Efficiency in Buildings: Teaming for Efficiency*, August 18-23, 2002, Asilomar, Pacific Grove, CA. Washington, D.C.: American Council for an Energy-Efficient Economy. LBNL-50855, Lawrence Berkeley National Laboratory, Berkeley, CA.

¹ All journal articles have been included as attachments to the final report.

² The first conference paper has been included as an attachment to the final report. The remaining are included in this attachment.

- Selkowitz, S.E., E.S. Lee, O. Aschehoug. 2003. Perspectives on Advanced Facades with Dynamic Glazings and Integrated Lighting Controls. CISBAT 2003, Innovation in Building Envelopes and Environmental Systems, International Conferences on Solar Energy in Buildings, October 8, 2003, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland.
- Selkowitz, S.E., O. Aschehoug, E.S. Lee. 2003. Advanced Interactive Facades – Critical Elements for Future Green Buildings? Presented at GreenBuild, the annual USGBC International Conference and Expo, November 2003. LBNL-53876.
- Selkowitz, S.E., E.S. Lee. 2004. Integrating Automated Shading and Smart Glazings with Daylight Controls. International Symposium on Daylighting Buildings (IEA SHC TASK 31), Tokyo, Japan.

Popular Press Articles³

- Engineering News-Record, “Glass Facades Go Beyond Skin Deep”, 2003.
- Builder Magazine, article on smart windows, February 2004.
- E-Source article on electrochromic windows, May 2004.*
- Berkeley Lab Currents, “Windows of Opportunity: New facility not only offers great views, but enables researchers to develop energy efficient windows”, September 19, 2003.
<http://www.lbl.gov/Publications/Currents/Archive/Sep-19-2003.html>
- Berkeley Lab Science Beat, “Internet-based control systems for building energy-efficiency”, November 26, 2003. <http://www.lbl.gov/Science-Articles/Archive/sb-EETD-internet-controls.html>
- Glass Magazine, “Chameleon Windows: Haven’t Shown Their True Colors Yet”, October 2004.*
- Scientific American, “Smart Glass: Private and Cool”, September 2005.*
- Energy design resources e-news, “High-Performance Glazing: Making the Most of Today’s Advanced Technologies”, Issue 54, March 2006. *
- Architectural Record, “Robo Buildings: Pursuing the Interactive Envelope”, April 2006.*

Presentations

- Selkowitz gave the opening paper: Energy Perspectives for Switchable Chromogenic Materials. IME-5 Conference in Denver, August 5-9, 2002.
- Selkowitz moderated a Round Table discussion on demand-responsive high-performance façades at the ACEEE 2002 Summer conference, August 2002.
- Selkowitz presented results from the EC program R&D at the PG&E Glazing Seminar, San Francisco, April 23, 2003.
- Selkowitz presented results from the EC field project at Glass Processing Days, Finland, June 2003.
- Selkowitz presented latest results and gave a tour of the Windows facility to ~40 people from DOE’s State Energy Advisory Board, July 10-11, 2003.
- Lee presented latest results to the Berkeley Breakfast Club, July 18, 2003.

³ LBNL staff were interviewed for many popular press articles, but for some, we never received a final copy of the article. For those where we did receive final copies, the article, noted with a (*) is included in this attachment or a website link is provided.

- Selkowitz gave a presentation and tour of the Windows facility to aides of Bay Area Legislators, July 29, 2003.
- Selkowitz and Lee gave a presentation and lab tour for the Mayoral Summit, September 19, 2003. The summit involved 50-60 mayors and aides from around the US. The Summit was also mentioned in Today at Berkeley Lab on 9/18/03. Acknowledgement of thanks from the San Francisco PUC.
- Selkowitz attended a DOE Energy Star windows meeting of about 100 window manufacturers in Washington DC on September 30, 2003 and discussed the current state of the electrochromic windows field test program.
- Selkowitz attended the International Energy Agency (IEA) Task 31 Daylighting meeting in Lausanne and presented a paper at the CISBAT Conference, Switzerland on dynamic window façade systems October 8, 2003. He toured the EPFL facility that is testing electrochromic glazings and met with German researchers who have been testing EC windows in Dortmund.
- Selkowitz attended a DOE roadmapping meeting in Phoenix, AZ, October 2003. Over 70 U.S.manufacturers attended the meeting. Selkowitz summarized the goals and status of the CEC-DOE electrochromic windows field test program.
- Lee gave a tour of the window testbed with the President of the Ana G. Méndez University System in San Juan, Puerto Rico, Mr. José F. Méndez and five other members of his staff, October 15, 2003.
- Lee gave a tour of the testbed facility to 35 members of the IEA Task 40 (commissioning HVAC systems), October 17, 2003.
- Met with John Durschinger, Skidmore Owings and Merrill Architects, at LBNL October 31, 2003 to discuss SOM's latest research program and its relation to this electrochromic windows project.
- Selkowitz presented a paper at the US Green Buildings Council Conference in Pittsburg, PA in November 2003, which included results from this project.
- Lee gave a tour of the testbed facility to eight members of the American Physical Society California Section and American Association of Physics Teachers Northern California/ Nevada Section, November 2003.
- A photo of the EC testbed was included in the "What the Future Holds" portion of the 2004 DOE EERE Calendar.
- A photo of the EC testbed was included in the LBNL Calendar.
- Selkowitz discussed generic issues of smart facades and integrated systems with The New York Times and several architectural firms and consultants in New York, New York, January 2004. Visited SOM in New York to review latest electrochromic results. Visited with Alliance to Save Energy staff and briefed them on progress with this project.
- Selkowitz and Lee gave an overview of our Windows and Daylighting Research at the California Energy Commission, February 5, 2004.
- Lee gave a tour of the Electrochromic Windows Facility February 5, 2004 for a Congressional staff visitor, Colin McCormick, who is on the staff of US Congressman Edward Markey. Markey is a senior member of the Energy and Commerce Committee.
- Lee gave a tour of the Electrochromic Windows Facility to a group of ~20 visitors from the China UN Industrial Development Organization, March 8, 2004.
- Selkowitz gave an overview of windows and daylighting research including a tour of the EC testbed facility to Norbert Young, President of the McGraw Hill Construction group (includes Architectural Record magazine, Engineering News Record, Dodge, Sweets, etc.), March 17, 2004.

- Selkowitz gave a presentation of LBNL advanced facades research, including early results from this EC project, at both the IEA Task 31 meeting in Tokyo, March 22-25, 2004 and at his keynote presentation at the ICBEST conference in Sydney, Australia, March 29-April 2, 2004.
- Lee gave a keynote presentation at Lightfair 2004, Las Vegas, March 29, 2004, which included the work from the EC testbed. A more detailed presentation of the EC field test work was also presented in a 1.5 hour seminar on advanced sidelighting.
- Selkowitz presented a paper on Integrated Façade Systems to the E-Source 7th Large Commercial Building Forum in San Diego to an audience of utilities and building owners, April 2004.
- Selkowitz presented an invited paper to Society of Vacuum Coaters 47th Annual Technical meeting in Dallas on Coated Glazings for Advanced Facades to an audience of glass and coating manufacturers, April 2004.
- Selkowitz presented an overview of the EC project at a meeting of the Technical Advisory Committee of the California Lighting Technology Center, Sacramento, CA, April 2004.
- Selkowitz presented an overview of the EC project and other advanced building control systems to faculty, students and facilities managers at Stanford University, April 2004.
- Selkowitz and Lee, EC Window Lab Tour for LBNL EETD Division review, May 13, 2004. Posters generated from this tour were sent to CEC.
- Selkowitz and Lee, Round table meeting at LBNL with industry and vendors, June 22, 2004, including The New York Times, GSA, and lighting control and automated shading vendors.
- Lee, panel discussion with industry and designers on dynamic façade and daylighting controls systems to the San Francisco AIA Chapter, June 29, 2004.
- Lee gave Spencer Abraham, Secretary of Energy, a tour of the Electrochromic Windows Testbed, July 7, 2004. See article: <http://www.lbl.gov/Publications/Currents/Archive/Jul-09-2004.html>
- LBNL's work on reflective hydrides (the next generation electrochromic window) received the prestigious R&D100 award. See article: <http://www.lbl.gov/Publications/Currents/Archive/Jul-09-2004.html>.
- Lee gave Kevin Carroll, Staff Director, Energy Subcommittee, US House of Representatives Committee on Science, a tour of the Electrochromic Windows Testbed in August 2004.
- Lee presented LBNL's latest research in automated façade and daylighting control systems at the IEA Task 31 Symposium held in Torino, Italy, September 21, 2004.
- Selkowitz presented LBNL's latest research on emerging smart facades systems at ACEEE Emerging Technologies Conference, San Francisco, October 14-15, 2004.
- Selkowitz presented EC R&D results at Glass Symposium, Syracuse, New York, October 21, 2004.
- Selkowitz presented EC R&D results at the Center for the Built Environment Annual Meeting, Berkeley, CA, October 25, 2004.
- Selkowitz presented EC R&D results at the SOM Building Science and Design Research Symposium, New York, NY, November 19-20, 2004.
- Selkowitz presented EC R&D results at the Center for Environmental Design Research, Invited Lecture, Berkeley, CA, November 12, 2004.
- Lee presented EC R&D results at the Illuminating Engineering Society Convention, Gold Coast, Australia, November 4-6, 2004.
- Lee presented this project's work to DOE in the DOE Windows Program Review, December 14, 2004.

- Selkowitz attended two NFRC meetings in Florida where he had an opportunity to discuss recent results of field test work, January 2005. He met with several glass and window manufacturers attending a non-residential rating meeting. SAGE Electrochromics, Inc. has been involved with NFRC to get rating protocols developed for their dynamic windows. Selkowitz participated in a strategic planning meeting of the Board of Directors.
- Lee and Selkowitz hosted Martha Krebs, CEC, at the EC windows test facility in March 2005. Martha had an opportunity to play with individual EC pane control and was informed of the capabilities of the testbed facility and nature of our research.
- Selkowitz gave a presentation that included this EC project at the Glass in Buildings conference in Bath, UK, on April 7, 2005.
- Lee and Glenn Hughes, The New York Times, gave a presentation on The New York Times daylighting and automated shade control project at the LightFair conference, April 11, 2005, in New York. EC project results were included in the presentation.
- Lee gave presentations of the EC work in the Subtask meetings of the IEA Task 31 meeting held in Berkeley, April 18-20.
- Lee presented results from EC R&D at the PG&E daylighting seminar for IEA Task 31-45 on April 21, 2005 in San Francisco.
- Lee presented results from this project at the DOE Windows Peer Review May 18, 2005.
- Lee and Glenn Hughes, NYT, gave a presentation on the AESP Lighting Conference in Albany, NY, May 25, 2005, including results from this EC R&D.
- Presentation of DOE-2 simulation results at the ISES Solar World Congress Conference in Florida, August 2005.
- Selkowitz presented results from this study at the Lux Europa conference in Berlin, September 19-21, 2005. Shared study results at the IEA Task 31 meeting in Berlin as well.
- Lee presented EC R&D to graduate student forum at the UC Berkeley Department of Mechanical Engineering, October 3, 2005.
- Lee presented results from this study at the Daylighting Symposium, Budapest, November 1, 2005.
- Lee presented results from EC R&D at the Center for the Built Environment Noon Time Seminar, UC Berkeley, November 16, 2005.
- Selkowitz presented (Lee convenor) results of this research at the USGBC Conference, Atlanta, GA, November 9, 2005.
- Selkowitz and Lee presented EC R&D results to Southern California Edison, Irwindale, January 27, 2006.
- Selkowitz presented latest in EC R&D to DOE Commercial Buildings Team, Washington DC, February 16, 2006.
- Selkowitz presented latest in EC R&D at International Glass Manufacturers Association, Indian Wells, February 24, 2006.
- Selkowitz and Lee, Seminar on Interactive Facades, LightFair 2006, Las Vegas, May 29, 2006.
- Lee, presentation of technical paper on EC project results, ASHRAE 2006 Summer meeting, Quebec City, June 24-28, 2006.